PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

issued by the

SMITHSONIAN INSTITUTION
U. S. NATIONAL MUSEUM

Vol. 92 | Washington: 1942 | No. 3143

THE SARDIS (GEORGIA) METEORITE

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In April 1940 a small, rusted fragment about the size of a half dollar was sent to the United States National Museum by Fred M. Allen, of the Chamber of Commerce in Waynesboro, Ga. Upon investigation it was found to be unusually heavy, and certain other properties suggested that it might be a meteorite. A chemical test on the specimen disclosed the presence of nickel. Further examination showed some of the unoxidized nickel-iron alloy, and these observations proved that it was a part of a meteorite. Mr. Allen was promptly notified of his find and was urged to furnish additional information, as well as a larger and better specimen for examination. He replied that the reported mass was believed to weigh several thousand pounds but said that he had not himself seen it.

The following month Mr. Allen submitted the second specimen and at this time corrected his former estimate of the size of the mass. Estimating the volume of the small specimen and knowing its weight he determined the weight per cubic inch of this material. After approximating the volume of the large specimen he predicted that it should weigh between 1,500 and 1,800 pounds. The meteorite actually was found to weigh 1,740 pounds.

In July, Mr. Allen wrote that his information had been furnished by the county sanitarian, W. H. Powell, and suggested that further correspondence be addressed to him. Mr. Powell was advised by letter of our interest in the specimen. The National Museum is greatly indebted to Mr. Allen for submitting the first sample and

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also to Mr. Powell for his spirit of cooperation, as well as for the manner in which he handled the removal of the meteorite.

Location and discovery.—The Sardis meteorite was recovered near Beaverdam Creek in the northern part of Jenkins County about 200 yards from the Burke County line. The nearest town is Sardis; therefore, it is proposed that this fall should bear its name. Sardis is in Burke County, but the specimen was found just over the line in Jenkins County. The place of discovery is 6¼ miles west-southwest of Sardis and 11 miles north-northeast of Millen, in latitude 32°56′56″ N. and longitude 80°51′54″ W. as given on the U. S. Geological Survey map of the Millen quadrangle.

Though the cottonfield in which this discovery was made has been under constant cultivation for about 50 years, the meteorite was not found until 1940, when a boy fouled his plow in such a manner as to cause him to investigate the obstruction. There was either something different in the manner in which the plow snagged that day or else the boy's interests had been freshly aroused by the frequent rumors of buried treasures often reported to be in this part of the country. When General Sherman made his famous march to the sea he passed through this area, and rumor still has it that the treasures of many families were buried to protect them from the invading army and have never been relocated. The plowman knew there were no rocks in this vicinity, so that anything causing his plow to snag was rather unusual and perhaps a hidden treasure. He probably guessed that his "pot of gold" lay right here.

He uncovered the object, undercut one side, and then assisted by neighbors dug a deep cavity under one side and turned it over into the new hole. Fortunately in the struggle to overturn it a few fragments were broken off. Because of the unusual weight of these pieces the finders' curiosity was aroused, and so they sought Mr. Powell's advice as to the nature of this rock.

The treasure hunt was perhaps a disappointment to these men because, after all their struggle, they found under it only orange-red sandy clay. After reburial the meteorite remained there for nearly a year until Mr. Powell by the assistance of a wrecking truck removed it from the field, crated it, and shipped it to the United States National Museum. Little did they realize that this heavy rock was not only a treasure but one of the five largest masses of meteoritic material ever to be found in this country. Its arrival on this earth probably preceded that of white man to this continent by countless centuries.

Description of the Sardis meteorite.—The over-all measurements taken in three directions at right angles to one another are 33 by 28 by 16 inches. The general shape is that of a flattened ellipsoid, but its present shape and dimensions are of little importance because an unknown amount of material has been removed by weathering. No features were found resembling either flight markings or the original crust of the meteorite.

In color and appearance the Sardis meteorite resembles a mass of limonite, but on closer examination a series of connecting fractures can be seen crossing the surface in a pattern resembling that made by the shrinkage cracks in sun-dried mud. Many of these fractures are as much as 2 inches deep, and on the sides of these can be seen traces of an octahedral structure.

The main mass of the Sardis meteorite weighs 1,740 pounds. As it is too heavy to be placed on the Museum's bandsaw, it will not be sectioned. It would be interesting to learn to what depth the unfractured meteorite has been altered.

When we removed the weathered soil from the place where this meteorite originally lay 20 pounds of small fragments were found. Some of these resembled a brown sandstone with hydrous iron oxide, limonite, acting as a cementing medium for the sand grains. After these pieces were cut and polished some of the larger areas of limonite were noted to have an octahedral structure, that is, it is meteoritic iron completely altered to a hydrous brown oxide.

The brown iron oxide, which served as a cementing medium for the sand grains, was found to contain considerable nickel. This indicates that the meteorite had been in part dissolved and carried away by groundwater. Also, some of the sand grains of the matrix are cemented to the fractured surfaces of the meteorite fragments, giving it the appearance of sandstone. The nickel apparently is partly retained in the iron oxide after precipitation, just as nickel and iron are precipitated together in the laboratory.

The polished surfaces of some of the pieces containing metallic iron show that the Sardis meteorite belongs to the coarse octahedrite group. Very little taenite and only one inclusion of troilite are present. A few very small inclusions of schreibersite were noticed. The alteration seems to have been most active along the boundaries between the kamacite areas.

The chemical composition of the Sardis meteorite is indicated by the following analysis (E. P. Henderson, analyst).

Fe	92. 08
Ni	6. 69
Co	0. 47
P	0. 24
S	trace
	99. 48

Topographic relations.—We did not visit the site until February 1941, which was several weeks after the meteorite had been received in the Museum. As Mr. Powell had stated in his letters, there were no scars on the surface. The field slopes gently northward from a rounded crest encircled by the 280-foot contour line to the south fork of Beaverdam Creek, which is 0.6 mile away and flows at an altitude of 220 feet above sea level. The meteorite lay about 250 feet above sea level and about midway between the top of the slope and the creek bed. Shallow wooded valleys leading to Beaverdam Creek lie just east and west of this field, and the two slopes grade evenly together. There is no indication that this plowed field has eroded very rapidly, nor is there any evidence of craterlike depressions.

After Mr. Powell pointed out the spot, we shoveled away the weathered, sandy soil down to the hardened surface on which the meteorite had rested. This proved to be compact, sandy clay of the Hawthorne formation of middle Miocene age, which at this place is covered by about 24 inches of loose sandy residual soil. Nothing was found in the Hawthorne sediments that could be taken as evidence of any distortion or disturbance. One would suppose that a freely falling body of this size would certainly crush or shatter even any consolidated rocks on which it fell. Surely this sandy clay, under the blow of so many thousand-foot pounds, would spatter away. The craterlike scar might not be preserved for an indefinitely long time, but such a depression would last for at least several hundred years. Plowing and harrowing would tend to erase such a scar, but it is doubtful if either normal cultivation or natural agencies would level it within a single century. The present owner of the land has tilled this field for nearly 50 years, and, as the farm belonged to his father, he would almost certainly have heard about it if such a large meteorite had fallen on his farm within the past 75 years.

General topographic features of this district suggest that erosion has not been very rapid. There is no apparent geological evidence to indicate that the general surface of this area has been reduced at a rate faster than 1 inch each 100 years; in all probability erosion has been at an even slower rate.

Depth of penetration.—Many factors, each with an almost unlimited number of variabilities, determine the depth to which a meteorite penetrates into the ground. Among the important factors are the rigidity of the meteorite, its shape, velocity of descent, and the nature of the material on which it landed. Meteorites of equal weight and velocity would not all bury themselves to the same depth in loose sand, because different meteoritic individuals have different rigidities. Some stony meteorites are rather friable when found, but just how firm these objects were prior to their impact with the earth is not known. It seems likely that iron meteorites, all other things being equal, would penetrate deeper than stony ones because of their greater rigidity or toughness.

The main mass of the Sardis meteorite. This is so deeply weathered that there is almost no external evidence to suggest that it is a meteorite.

Coarse octahedrite (natural size). This section was cut from a fragment found by the authors. The dark weathered zone at the left slopes down from the plane of the polished face.

Velocity and the angle of incidence are important factors in determining the depth of penetration. An individual stone of the Hessle[1] fall weighing about 4 pounds was found on a frozen lake where it fell at a time when the ice was only a few inches thick. An object of this weight falling from only a mile high would exert 21,200 foot-pounds of energy, which surely would be sufficient to puncture the ice if this force were applied in a direction normal to the surface.

Since the individual stone failed to break the ice, the meteorite must have either approached the ice with a high angle of incidence or for some reason had its velocity greatly reduced. Recorded statements of eyewitnesses indicate that the Hessle meteorite had a remarkably small downward velocity.

The Allegan, Mich., meteorite weighing 70 pounds penetrated a sandy soil only about 18 inches, but this stony fall, when recovered, was considerably shattered. The 660-pound Knyahinya stony meteorite struck the ground at an estimated angle of about 25° from the vertical and penetrated to a depth of 11 feet. The Hraschina, a 71-pound iron, was reported to have penetrated 18 feet; the 820-pound Paragould, Ark., stone, a witnessed fall, penetrated the clay soil to 8 feet. The Hugoton, Kans., meteorite, a 749-pound stone, was recovered in a cornfield where it, too, was discovered by fouling the plowpoint. The base of the Hugoton was only 3 feet below the present surface of the field, but this stone may be a very old fall, and much of its covering had been eroded away.

Nininger[2] has summarized some information on the average depths of individuals according to their weight:

Number of individuals	Weight of specimen	Depth of penetration
	Pounds	*Inches*
6	50–100	32
7	100–200	43
2	200–400	48

In the Odessa crater of Ector County, Tex., which has been under investigation for some time, recent work indicates that perhaps a large mass of this fall has been located. "Two test holes, 10 feet apart, encountered at a depth of 164 feet, a mass that was essentially unaffected by pounding of the 1,500-pound drilling bit. This is believed to be a meteorite."[3]

[1] Flight, Walter, History of meteorites, p. 2, 1887. London.

[2] Nininger, H. H., Depth of meteorites and gradation of the Great Plains. Journ. Geol., vol. 44, No. 1, p. 66, 1936.

[3] Sellards, E. H., Private communication.

As the Sardis iron meteorite is sufficiently firm to withstand the impact with the earth without failing, it should have been able to penetrate sandy soil to a depth of more than 6 feet. The base of the Sardis rested somewhere between 24 and 30 inches below the present surface of the plowed field. This would indicate, if any value whatsoever can be attached to the conservative estimate of the 6-foot penetration, arrived at indirectly, that at least 48 inches of sediment has been removed from above this meteorite since it fell.

If 4 feet of sediment has been removed from this surface, the top of the unweathered Hawthorne was once well above the uppermost part of the Sardis meteorite, for the bottom of the soil zone tends to weather down as the top is removed. Loose sand derived from the Hawthorne formation would have been the material scattered by the impact of the meteorite, but erosion long ago has removed that old weathered soil, and thus carried away all traces of its crater. Likewise, if the compact Hawthorne beds had been shattered by the impact, the weathering agents and circulating waters would tend to obliterate all effects of the disturbance.

Time of fall.—For reasons already stated it seems likely that the Sardis meteorite did not fall within the past century. Even had it struck elsewhere and ricocheted to its last resting place at any time within the past hundred years, vivid stories of a falling star or some unusual phenomenon would probably still be well known by some of the older generation living in the neighborhood. However, the question of whether it fell several thousand years, a million, or even 10 million years ago is problematical, and only indirect reasoning can be applied to date its fall. Aerial photographic maps of this district fail to show any craterlike scars within a radius of several miles that even remotely resemble a meteoric scar.

The Sardis meteorite is deeply weathered, and this weathering in itself would require considerable time; but here, again, no definite rate of weathering can be determined, as different meteorites have different degrees of stability. It is true that the Sardis specimen is not the most stable of irons. Polished sections cut from some of the larger fragments that display some iron-nickel alloy will tarnish within a few weeks when exposed to the atmosphere in the Museum; however, we have every reason to believe that if this same specimen were exposed in the open outside air, it would be much more stable. It is difficult to prove this by reasoning, but actual experience shows that some meteorites placed in the open actually disintegrate less rapidly than when placed inside a building.

As stated, the Sardis meteorite may have fallen a great many thousand years ago and have buried itself very deeply into the exposed Hawthorne formation. The estimate of 72 inches is only a conservative speculation; it might have penetrated deeper, and, if so, the geological evidence of a scar would definitely be eroded by now. This part of the Coastal Plain has little relief, and Beaverdam Creek, the principal drainage system of the immediate vicinity, has a gradient of only 10 feet in a mile. Thus erosion is extremely slow, and to remove 48 inches or more of surface might require several thousand years.

It is likewise possible that the Sardis meteorite fell into the sea in Miocene times and had its impact cushioned by striking the water, in which it gently settled to the bottom and was buried by the slowly accumulating Hawthorne formation. If this were true, corrosion would be active for a while, but the thickening oxide crust would offer increased protection as time elapsed. Furthermore, the sediments would, in all probability, soon cover it, thereby decreasing the circulation of water and retarding the rate of alteration. If the Sardis iron was incorporated in the Miocene beds at the time of their formation, the meteorite would not have become exposed to rapidly circulating water or air until late Pleistocene time or possibly until the Recent epoch, by which time a considerable thickness of upper Miocene and Pliocene sediments had been removed, and the level of permanent saturation had fallen below the meteorite.

Relation to depressions and elliptical bays.—As there are many depressions of various shapes and sizes within a few miles of the place where the Sardis meteorite was recovered, we considered the possibility that some of them might be meteorite scars. For reasons given earlier in this paper, we are inclined to believe that the Sardis meteorite fell in the far distant past, probably in Miocene time, and that any scar in the rocks made by it has long since been obliterated.

There are many depressions of various sizes between Spring Mill Branch and Little Buckhead Creek, 5 to 10 miles southwest of the place where the Sardis iron was found. A depression about one-eighth of a mile long and nearly as wide lies about three-quarters of a mile southwest of Perkins, 7 miles away. There is another bay northwest of Perkins. A bay about one-half mile long by three-eighths mile wide lies about one and one-quarter miles east by north of Magnolia Spring and 6 miles southwest of the spot.

About 10 miles west-northwest of the site of the Sardis find there are several parallel depressions about three-eighths of a mile long by about one-quarter of a mile wide extending a few degrees east of south.

These depressions or bays are considered by C. W. Cooke to be sinks made by solution of the Cooper marl, which crops out at Magnolia Spring on Spring Mill Branch.

Another group of sinks near the head of Beaverdam Creek, 3 to 5 miles northwest of this find, presumably is the result of solution of a calcareous bed in the Barnwell formation, which immediately underlies a thin cover of overlapping Hawthorne formation in that region. Several ponds about 12 miles north of the Sardis site and occupying depressions in the Barnwell formation, indicate either solution of the Barnwell or the McBean formation, which lies beneath the surface. Both formations contain soluble beds.

Besides these comparatively small ponds and bays of somewhat irregular shape and orientation, which obviously were formed by solution, aerial photographs reveal on the plains of South Carolina 20 miles east several groups of much larger but very shallow elliptical depressions, all trending N.45°W. These are of the "Carolina bay" type, about whose origin there has been much speculation.[4] We are of the opinion that these bays are not scars of meteorites, as has been suggested. They are much too shallow in proportion to their area, many being much more than 200 times as wide as deep, whereas craters of known meteoritic origin range from 29.4 to 6 times.[5]

The Sardis meteorite, because of its size, represents one of the most important meteorites of this country. If the total known weight of this fall is compared with the total known weights of other falls, the Sardis stands as the tenth on the list of meteorites from the United States. It is of more importance than that because only five larger meteoritic specimens have so far been found in this country.

The following list gives in descending order of their total recorded weights the 11 largest known meteorites ever to have fallen in this country. Such weights are never accurate, and perhaps in cases such as Canyon Diablo and Brenham they are far too conservative.

[4] Melton, F. A., and Schriever, William, The Carolina bays—are they meteorite scars? Journ. Geol., vol. 41, pp. 52–66, 1933.

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———. Role of artesian waters in forming the Carolina bays. Science, new ser., vol. 86, pp. 255–258, 1937.

[5] Spencer, L. J., Geogr. Journ., vol. 81, No. 3, Mar. 1933.